Building Scalable Web Sites:

Tidbits from the sites that made it work

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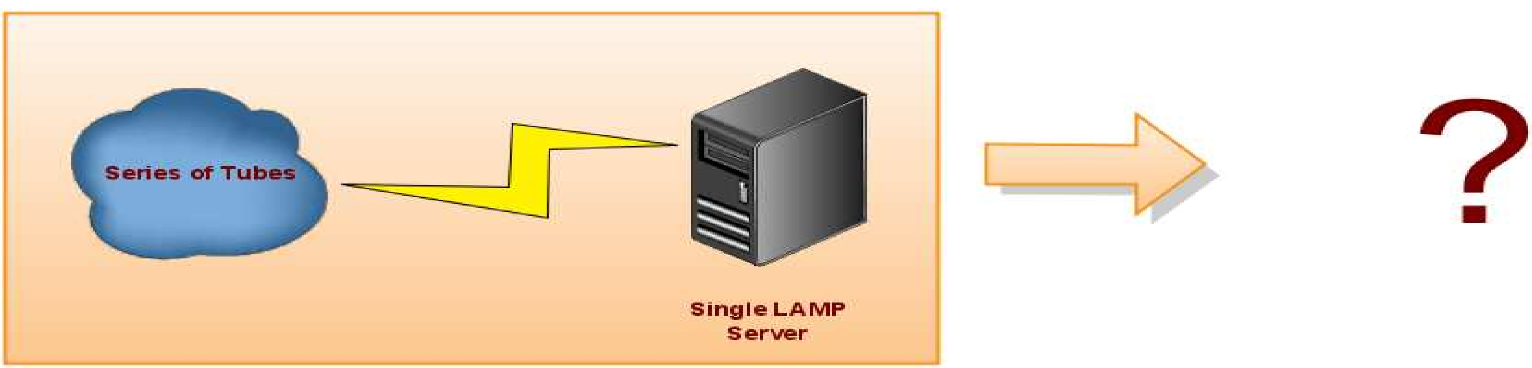
What Is This About

- "Scalable" is hot
- Web startups tend to die or grow... really big
    - **Youtube – Founded 02/2005. Acquired by Google 11/2006**
        - 03/2006 – 30 million videos a day
        - 07/2006 – 100 million videos a day
- Start with small budget
- LAMP
- Scale, but try to use commodity hardware
- Can't we just throw some more servers at the problem?

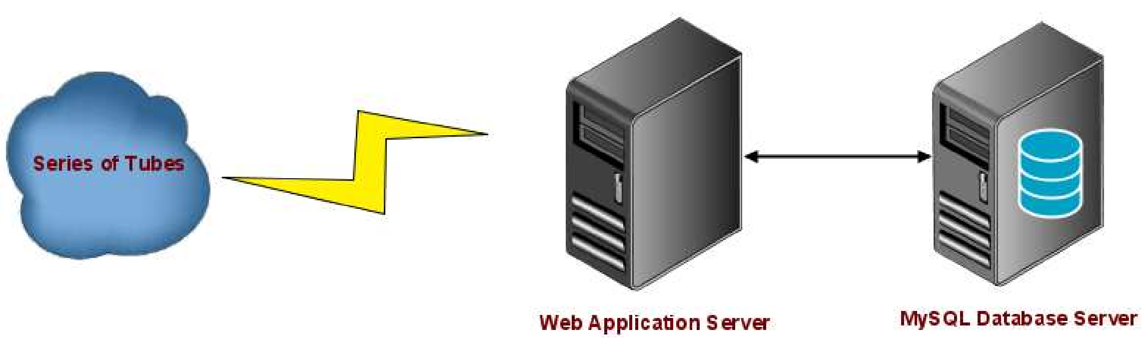


Cred?

- **I have no cred**
  - **Desktop apps**
  - **C++**
  - **Python for kicks**
- **But these guys do:**
  - **Chung Do (YouTube)**
  - **Cal Henderson (Flickr)**
- **So lets talk about**
  - **Software**
  - **Hardware**
  - **Databases**

What It Breaks Down Into

- **Web Application**
  - **Apache**
  - **+ module friends**
  - **Python/PHP (no perl thank god)**
- **Database Server**
  - **MySQL**
  - **Memcache (more later)**
- **Content**
  - **Images**
  - **Videos**
- **High load?**
  - **Punt. Dual-quad Opteron with 16GB of RAM will go a long, long way.**



Really? No hand crafted C?

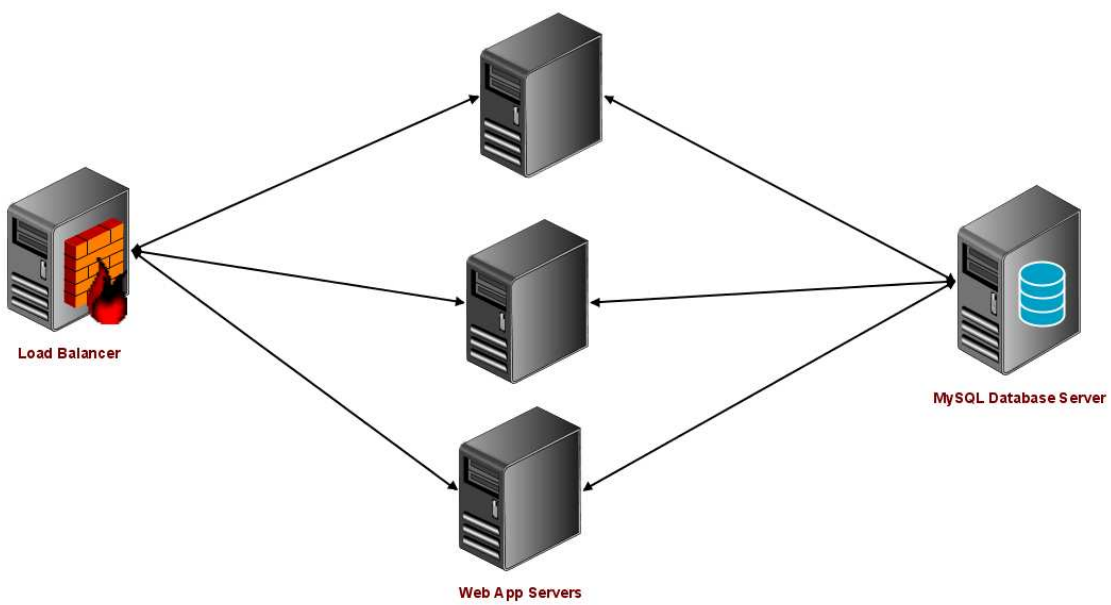
- **Wait? Aren't Python/PHP slow?**
- **Doesn't matter: They are fast enough**
- **What does matter: Developer time**
- **All the time gets spent:**
  - **On the wire (serving files, RPC, server communication)**
  - **Database**
- **But there are optimizations at every level**
- **Caching at every level**

The Web App

- **Build dynamic HTML**
- **Youtube used:**
  - **Apache with mod_fastcgi and Python**
  - **psyco (dynamic python -> C compiler)**
  - **A few C extensions for encryption**
- **Flickr used:**
  - **Apache with ? and PHP**
  - **Custom PHP framework**
  - **Async web design – requests get quick response, poll on status of server intensive tasks**
- **Cache?**
  - **Pre-generated, entire HTML for high traffic pages**

Scaling Web Servers

- **Load balancing**
- **Hardware (Layer 4 or Layer 7)**
  - **Bigger, faster, stronger**
  - **More expensive**
  - **Alteon, Cisco, Netscaler (YouTube), Foundry, etc**
- **Software (still need hardware)**
  - **mod_backhand**
  - **whackamole**
- **End up integrating with your reverse proxy/CDN (more later)**



Scaling the DB

- Read/Write ratio generally 80/20 or 90/10
- Scale read capacity: MySQL replication
- Master (for writes) <-> Many slaves (for reads)
  - Writes go through master, propagates to all slaves
  - Does not scale
  - Soon slaves are spending 80% time syncing writes (unhealthy)
  - Propagation delay increases (read old values)
  - YouTube hacked MySQL master
    - Cache primer thread that pre-fetches reads of queries from disk to prevent stalling while handing write queue. Bought them time
- Master <-> Master pair
  - Provides High Availability
  - Reads faster than single master
  - Limits at most doubled
  - Still have row table limits etc
- Pragmatic solution…

Partitioning, Sharding, Federated Data

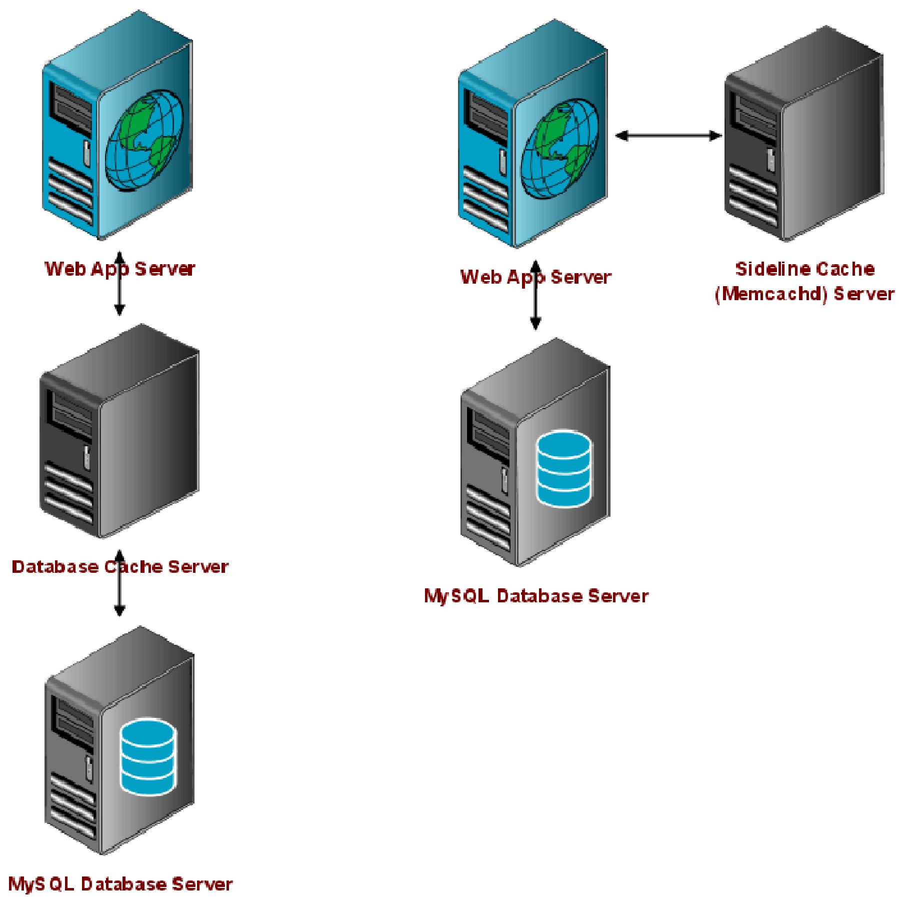
- **Vertical Partitioning**
  - Create partition of tables that will never need to be joined
  - Logical limits depending on application
- **Horizontal Partitioning – Sharding**
  - Same schema, partition by some primary field (like user)
  - Place each shard on a cluster (master-master pair?)
  - Spreads reads and writes
  - Better cache locality
  - Must avoid shard walking
  - Don't assign to shard algorithmically
  - Requires central lookup cluster (hash table) to map user to shard

Shards Cont

- **Advantages**
  - **Need more capacity? Just add more shards**
  - **Heterogeneous hardware is fine, just assign less/more objects per shard**
- **Disadvantages**
  - **App logic gets more complicated**
  - **More clusters to manage**
  - **Constrains lookups**
- **Denormalization – Performance trick (not sharding)**
  - **'Copied' field from main table to linking table to make queries faster**
  - **Cached fields: Say in a parent/child relationship, cache count**

Database Caching

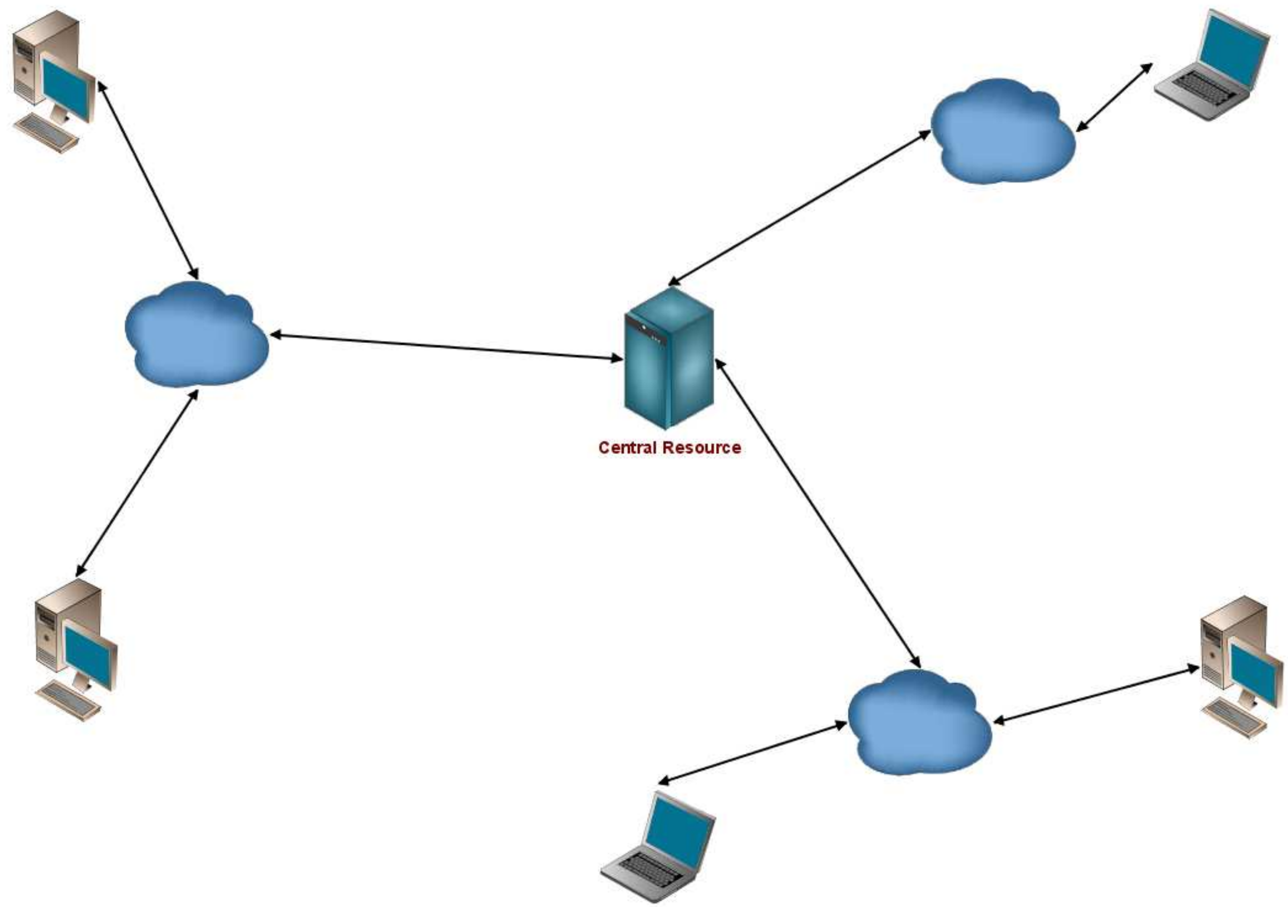
- **Write-through cache**
- **Write-back cache**
- **Sideline cache**
  - **Takes application logic (manually invalidate)**
  - **Usually best**
  - **Memcached**



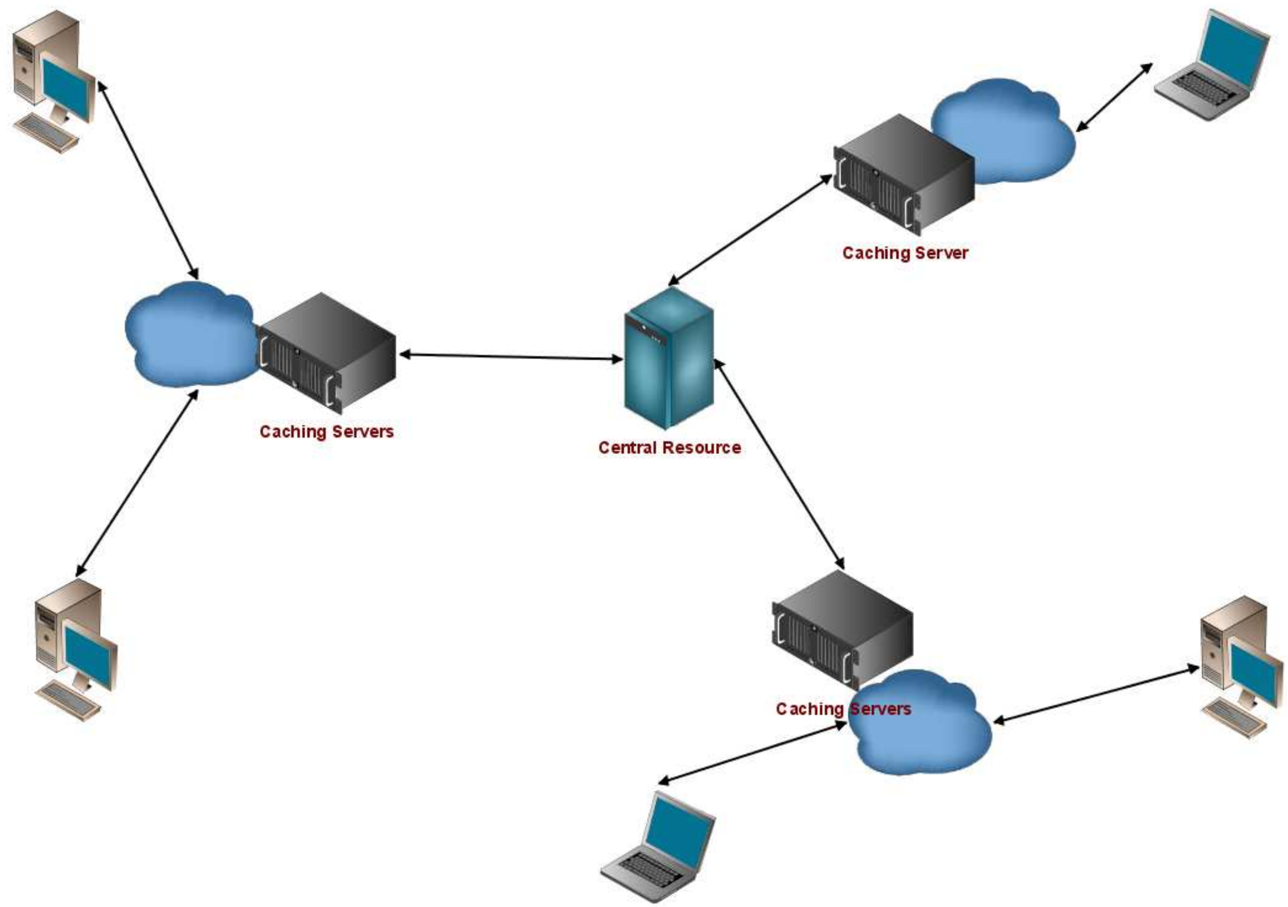
Content Caching

- **Reverse proxy/Caching proxy – can be geographically dispersed**
  - Scales well
  - Fast – usually serve out of memory
  - Dealing with invalidation is tricky
  - Direct prodding to invalidate scales badly
  - Instead, change URLs of modified resources
  - Old ones will drop out of cache naturally
- **CDN – Content Delivery Network**
  - Akamai, Savvis, Mirror Image Internet, Netscaler, etc
  - Operated by 3rd parties. Already in place
  - Gives you GSLB/DNS balancing (Global Server Load Balancing)
  - Once something is cached on CDN, assume that it never changes.
  - SSL can be at proxy point with SSL hardware
  - Sometimes does load balancing as well

CDN



CDN



Caching Server
Caching Servers
Central Resource
Caching Servers

Content Caching Cont

- **Versioning**
  - **Rule of thumb: if item is modified, change it's URL**
  - **Independent of your file system, can use mod_rewrite etc**
- **Tools**
  - **Squid (web cache, proxy server), GPL**
  - **Mod_proxy and mod_cache for Apache**
  - **Perlbal (mostly load balancer) and memcached**

Sessions

- Non-trivial assuming load balanced application servers
- Local == bad:
  - PHP sessions are stored locally on disk
  - Can’t move users, can’t avoid hotspots, no fault tolerance
- Mobile local sessions:
  - Store last session location in cookie
  - If request gets to different server, then pull session info
- Single centralization database (or in-mem cache)
  - No hot spots, porting of session data, good
  - Problems scaling, bad
- Stash the whole damn session in a cookie!
  - “user_id + user_name + time + secret”-> sign -> base64
  - Timestamp can expire it
  - User_name is usually most used user info (“hello user_name”)
  - Fewer queries per page (some pages need little personalization)

Authentication (private and privileged content)

- **Perlbal – reverse proxy can handle custom authentication modules**
- **Bake permissions into URL**
  - **Can do auth at web app**
  - **Use magic to translate URL to real resource paths**
  - **Don’t want paths to be guessable**
  - **Skips need for Perlbal or re-proxy step**
  - **Downsides:**
    - permission for live
    - Unless you bake in an expiring token
    - Ugly URLs?
  - **Upsides:**
    - scales very nicely and works

File Storage

- Eventually outgrow single box's capacity
- Horizontal scaling
- Remote file protocol?
  - NFS – stateful == sucks
  - SMB/Samba – stateful but degrades gracefully
  - HTTP – Stateless!
- At some point need multiple volumes
- At some point need multiple hosts
- Also want high availability and failure recovery (rebuild)
- So we can ignore RAID

Distributed fault tolerant file systems

- **MogileFS – application level distributed file system**
  - **Metadata store (MySQL – can be clustered)**
  - **Replication automatic and piecemeal**
  - **I/O goes through tracker nodes that use storage nodes**
- **GFS – Google File System (proprietary)**
  - **"Master" node holds metadata (shadow master for warm swap)**
  - **Master node manages I/O (leases)**
  - **Grid of 'chunkservers', files usually dispersed among many servers**
  - **Designed to read large files fast**
  - **Automatic replication and self repairing**
- **Flickr File System - proprietary**
  - **No metadata store**
  - **App must store metadata – virtual volume number**
  - **StorageMaster nodes responsible for writing (organization)**
  - **Virtual nodes store data, are mirrored**
  - **Reading is done directly from nodes (scales really well)**
- **Amazon S3 – big disk in the sky**
  - **Files have user-defined keys**
  - **Data + metadata**
  - **Cost, linear and gets expensive as you scale**

Story – YouTube thumbnails

- **Loads of them (a dozen per video)**
- **Lots of disk seeks**
- **High # requests/sec (when you search, you get back thumbnails)**
- **Lots of files in the filesystem**
  - **Start to blow per-directory limits**
  - **Move to hierarchial storage**
  - **Sync between servers really slow**
- **Interim solution**
  - **Move from Apache to lighttpd**
  - **Then hack lighttpd to have I/O bound worker threads (it's open source)**
- **Long term solution**
  - **Google Big Table**
  - **Avoid small file problem**
  - **Get fault tolerance**
  - **Distributed access**
  - **Caching**

End

- Building Scalable Web Sites: Building, scaling, and optimizing the next generation of web applications -- Cal Henderson
- Scalable Internet Architectures -- Theo Schlossnagle